

(19)



(11)

EP 3 733 361 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
23.08.2023 Bulletin 2023/34

(51) International Patent Classification (IPC):
B25J 9/16 ^(2006.01) **G05B 19/4062** ^(2006.01)
G05B 23/02 ^(2006.01)

(21) Application number: **17936814.7**

(52) Cooperative Patent Classification (CPC):
B25J 9/1674; B25J 19/06; G05B 19/4062;
G05B 23/0245; G05B 2219/37435

(22) Date of filing: **26.12.2017**

(86) International application number:
PCT/JP2017/046666

(87) International publication number:
WO 2019/130430 (04.07.2019 Gazette 2019/27)

(54) **MALFUNCTION DETERMINATION METHOD AND MALFUNCTION DETERMINATION DEVICE**

VERFAHREN ZUR BESTIMMUNG EINER FEHLFUNKTION UND VORRICHTUNG ZUR
BESTIMMUNG EINER FEHLFUNKTION

PROCÉDÉ DE DÉTERMINATION DE DYSFONCTIONNEMENT ET DISPOSITIF DE
DÉTERMINATION DE DYSFONCTIONNEMENT

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
04.11.2020 Bulletin 2020/45

(73) Proprietors:
• **NISSAN MOTOR CO., LTD.**
Yokohama-shi, Kanagawa 221-0023 (JP)
• **Renault s.a.s**
92100 Boulogne Billancourt (FR)

(72) Inventors:
• **TANAKA, Yasuhiro**
Atsugi-shi
Kanagawa 243-0123 (JP)

• **URAKAWA, Toshimichi**
Atsugi-shi
Kanagawa 243-0123 (JP)
• **TAKAGI, Toru**
Atsugi-shi
Kanagawa 243-0123 (JP)
• **TOMIKASHI, Minoru**
Atsugi-shi
Kanagawa 243-0123 (JP)

(74) Representative: **Osha Liang**
2, rue de la Paix
75002 Paris (FR)

(56) References cited:
WO-A1-2016/189608 WO-A1-2016/194029
DE-T5-112016 001 030 JP-A- 2002 175 104
US-A1- 2007 244 609 US-A1- 2019 099 886

EP 3 733 361 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a malfunction determination method and a malfunction determination device for acquiring sensor data of a sensor that detects a condition of a production machine including a motor as a driving source of a rotating mechanism, so as to determine a malfunction of the production machine.

BACKGROUND ART

10 **[0002]** An abnormal load detection device is known that detects an abnormal load applied to a motor, as disclosed in Patent Document 1. The abnormal load detection device disclosed in Patent Document 1 determines that the current operation is in a normal state without detecting an abnormal load when a rotation speed of the motor falls below a reference speed, such as when the motor stops, starts rotating, or rotates at a low speed, since such a situation tends to lead to false detection of an abnormality. Other abnormal load detection devices are disclosed in Patent Document 2 and Patent Document 3.

CITATION LIST

20 PATENT LITERATURE

[0003] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2007-219991, Patent Document 2: JP 2002 175104 A, Patent Document 3: US 2007/244609 A1.

25 SUMMARY OF INVENTION

TECHNICAL PROBLEM

30 **[0004]** The method disclosed in Patent Document 1 still has a problem of false detection in a production machine such as a production robot, which is sometimes determined to have a malfunction regardless of the operational condition of the motor, such as a rotation speed. For example, the production machine, which has stopped its operation for a long period of time but then starts the operation, may be wrongly determined to have a malfunction immediately after the start even though there is no malfunction in the production machine. The method disclosed in Patent Document 1 thus cannot avoid false detection of a malfunction in the production machine which has not been operated for a long period of time, since the operating state of the production machine has no relationship with the operational condition of the motor.

35 **[0005]** In view of the foregoing problem, the present invention provides a malfunction determination method and a malfunction determination device capable of preventing false detection of a malfunction of a production machine under circumstances having no relationship with an operational condition of a motor, such as when the production machine has stopped its operation for a long period of time.

40

TECHNICAL SOLUTION

[0006] A malfunction determination method and device according to the invention are defined in the appended independent claims. Specific embodiments are defined in the dependent claims.

45

ADVANTAGEOUS EFFECTS

50 **[0007]** The present invention can provide the malfunction determination method and device capable of preventing false detection of a malfunction of the production machine made under the circumstances having no relationship with an operational condition of a motor, such as when the production machine has stopped its operation for a long period of time.

BRIEF DESCRIPTION OF DRAWINGS

55 **[0008]**

[Fig. 1] Fig. 1 is a block diagram illustrating a configuration of a malfunction determination system including a malfunction determination device according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a flowchart illustrating a procedure of malfunction determination processing by the malfunction determination device according to the first embodiment of the present invention.

[Fig. 3] Fig. 3 is a diagram for explaining a malfunction determination method by the malfunction determination device according to the first embodiment of the present invention.

[Fig. 4] Fig. 4 is a diagram for explaining a method of setting a malfunction determination suspension period by the malfunction determination device according to the first embodiment of the present invention.

[Fig. 5] Fig. 5 is a block diagram illustrating a configuration of a malfunction determination system including a malfunction determination device according to a second embodiment of the present invention.

[Fig. 6] Fig. 6 is a diagram for explaining a method of setting a malfunction determination suspension period by the malfunction determination device according to the second embodiment of the present invention.

[Fig. 7] Fig. 7 is a diagram for explaining a malfunction determination method by the malfunction determination device according to the second embodiment of the present invention.

[Fig. 8] Fig. 8 is a diagram for explaining the malfunction determination method by the malfunction determination device according to the second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[First embodiment]

[0009] A first embodiment according to the present invention will be described below with reference to the drawings. The same elements illustrated in the drawings are indicated by the same reference numerals, and specific explanations are not repeated below.

[Configuration of malfunction determination system]

[0010] Fig. 1 is a block diagram illustrating a configuration of a malfunction determination system including a malfunction determination device according to the present embodiment. As shown in Fig. 1, the malfunction determination system 100 according to the present embodiment includes a production robot 1, a malfunction determination device 3, and a user interface 5.

[0011] The production robot 1 is a production machine including a plurality of motor drive systems as joint shafts. The motor drive systems include a motor as a driving source of a rotating mechanism of a robot arm, for example. The motor drives the robot arm via a reducer. The production robot 1 includes a sensor 11, a calculation unit 13, and a communication unit 15.

[0012] The sensor 11 detects a condition of the production robot 1 including various kinds of data on the motor drive systems necessary for determining a malfunction of the production robot 1. For example, the sensor 11 detects a rotational angle position, speed, and torque value of the motor, and a vibration value of the rotating mechanism such as the reducer. The calculation unit 13 obtains a difference between the torque value detected by the sensor 11 and a motor control value so as to calculate a disturbance torque value. The communication unit 15 has a function of communicating necessary data with the malfunction determination device 3 through a local area network (LAN), for example. In particular, the communication unit 15 transmits sensor data indicating the condition of the production robot 1. The sensor data includes the rotational angle position, speed, and torque value of the motor, the vibration value of the rotating mechanism, and the disturbance torque value.

[0013] The malfunction determination device 3 acquires the sensor data of the sensor 11 for detecting the condition of the production robot 1 so as to determine a malfunction of the production robot 1. The malfunction determination device 3 includes a communication unit 21, an operation status determination unit 23, a suspension period setting unit 25, a malfunction determination unit 27, a sensor information database 29, a maintenance history database 31, and an operation history database 33. The malfunction determination device 3 is implemented by a general-purpose electronic circuit including a microcomputer, a microprocessor, and a CPU, and a peripheral device including memory. The malfunction determination device 3 serves as the communication unit 21, the operation status determination unit 23, the suspension period setting unit 25, and the malfunction determination unit 27 when a predetermined program is executed. The respective functions of the malfunction determination device 3 can be implemented in single or plural processing circuits. The respective processing circuits include a programmed processing device, such as a processing device including an electric circuit, including an application-specific integrated circuit (ASIC) configured to execute the functions described in the embodiment or conventional circuit components.

[0014] The communication unit 21 has a function of communicating necessary data with the communication unit 15 of the production robot 1 through the LAN, for example. In particular, the communication unit 21 receives the sensor data indicating the condition of the production robot 1.

[0015] The operation status determination unit 23 determines whether the production robot 1 has an operation stop

period during which the production robot 1 has stopped its operation for a predetermined period of time or longer, in accordance with the operation history of the production robot 1. In particular, the operation status determination unit 23 acquires an operation start time and date and an operation stop time and date of the production robot 1 from the operation history database 33 to calculate the operation stop period. The operation status determination unit 23 then compares the calculated operation stop period with a predetermined threshold so as to determine whether the production robot 1 has the operation stop period during which the production robot 1 has stopped the operation for a predetermined period or longer. For example, the operation status determination unit 23 determines whether there are operation stop periods of six hours or longer, two days or longer, ten days or longer, and twenty days or longer.

[0016] The suspension period setting unit 25 sets a malfunction determination suspension period during which the determination of a malfunction of the production robot 1 is suspended, in accordance with the length of the operation stop period when the production robot 1 is determined to have the operation stop period. The malfunction determination suspension period is set from a point at which the production robot 1 starts operating after the operation stop period ends. The determination of a malfunction of the production robot 1 by the malfunction determination unit 27 is suspended during the malfunction determination suspension period.

[0017] When a production machine has not been operated for a long period of time, viscosity of lubricating oil, for example, typically tends to increase. As a result, an abnormally large value could be output as a disturbance torque value when the production machine has not been operated for a long period of time but then starts operating, which may lead to false detection of a malfunction even though there is no malfunction in the production machine. The suspension period setting unit 25 thus sets the malfunction determination suspension period immediately after the operation stop period in accordance with the length of the operation stop period, so as to prevent false detection of a malfunction. Since the viscosity of lubricating oil is increased as the operation stop period is longer, the suspension period setting unit 25 sets the malfunction determination suspension period to be longer as the operation stop period is longer.

[0018] The malfunction determination unit 27 determines whether the production robot 1 has a malfunction by use of the sensor data indicating the condition of the production robot 1. In particular, the malfunction determination unit 27 acquires the sensor data during a predetermined period from the sensor information database 29 to determine whether the production robot 1 has a malfunction. The determination of a malfunction includes a process of calculating a malfunction determination value such as a difference rate of the disturbance torque to determine a malfunction of the production robot 1 depending on whether the malfunction determination value is a predetermined threshold or greater.

[0019] When the production robot 1 has a predetermined operation stop period or longer, the malfunction determination unit 27 determines whether the production robot 1 has a malfunction in a period other than the malfunction determination suspension period. Namely, the malfunction determination unit 27 determines whether the production robot 1 has a malfunction by use of the sensor data for a period other than the malfunction determination suspension period.

[0020] The sensor information database 29 accumulates the sensor data indicating the condition of the production robot 1. For example, the sensor information database 29 acquires and accumulates, through the respective communication units 15 and 21, data including the rotational angle position, speed, and torque value of the motor, and the vibration value of the rotating mechanism detected by the sensor 11, and data including the disturbance torque value calculated by the calculation unit 13.

[0021] The maintenance history database 31 accumulates maintenance history data of the production robot 1. For example, the maintenance history database 31 accumulates maintenance records including a date on which the reducer was replaced, and a time and date at which grease was reapplied.

[0022] The operation history database 33 accumulates operation history data including a time and date at which the production robot 1 started the operation and a time and date at which the production robot 1 stopped the operation.

[0023] The user interface 5 is a display device such as a monitor or a tablet device for displaying a determination result of a malfunction or an alert picture, or giving an alarm.

[Malfunction determination processing]

[0024] A malfunction determination method by the malfunction determination device 3 according to the present embodiment is described below with reference to Fig. 2. Fig. 2 is a flowchart illustrating a procedure of the malfunction determination processing by the malfunction determination device 3.

[0025] In step S101 shown in Fig. 2, the malfunction determination unit 27 acquires the sensor data accumulated in the sensor information database 29. In particular, the malfunction determination unit 27 acquires a piece of data for one of the periods preliminarily divided at regular intervals. The data to be acquired includes a disturbance torque and a vibration value of the rotating mechanism. The malfunction determination unit 27 also acquires the maintenance history data of the production robot 1 from the maintenance history database 31. The maintenance history to be acquired includes a date of replacement of the reducer and a time and date of grease reapplication. The malfunction determination unit 27 does not necessarily acquire the sensor data from the sensor information database 29, and may acquire the sensor data from the production robot 1 in real time.

[0026] In step S103, the malfunction determination unit 27 calculates the malfunction determination value by use of the sensor data. The malfunction determination value is a statistical value to be calculated for determining a malfunction of the production robot 1. For example, when the data of the disturbance torque is selected from the sensor data, the difference rate of the disturbance torque is used as the malfunction determination value. The difference rate of the vibration value of the rotating mechanism may also be used as the malfunction determination value. Any other statistical value such as an average value enabling the determination of a malfunction of the production robot 1 may be used instead of the difference rate.

[0027] The difference rate is a rate of change of a measurement value with respect to a predetermined reference value. The difference rate of the disturbance torque is given by the following equation (1) using a reference value:

$$\text{Difference rate} = (\text{disturbance torque measurement value} - \text{reference value}) / \text{reference value} \dots (1)$$

[0028] The reference value may be an average value of disturbance torques in the same month of the previous year, for example. Any other value that can be a reference for determining a malfunction of the production robot 1 may be used as the reference value. For example, an average value of disturbance torques during the operation stop period may be used as the reference value when the production robot 1 is used in a region with no change in season or temperature.

[0029] In step S105, the malfunction determination unit 27 compares the malfunction determination value with a predetermined threshold so as to determine whether the production robot 1 has a malfunction. For example, as shown in Fig. 3, when the difference rate of the disturbance torque is used as the malfunction determination value while the threshold is set to 20%, the production robot 1 is determined to have a malfunction when the difference rate of the disturbance torque is 20% or greater. The process proceeds to step S107 when there is a malfunction. The production robot 1 is determined to have no malfunction when the difference rate is less than 20%. The process returns to step S101 when there is no malfunction so as to acquire the sensor data for the period subsequent to the current malfunction determination to continuously execute the malfunction determination.

[0030] In step S107, the operation status determination unit 23 acquires the operation history data of the production robot 1 from the operation history database 33. The operation history data to be acquired includes the operation start time and date and the operation stop time and date of the production robot 1.

[0031] In step S109, the operation status determination unit 23 determines whether there is any operation stop period during which the production robot 1 has stopped its operation for a predetermined period of time or longer based on the acquired operation history data. In particular, the operation status determination unit 23 acquires the operation start time and date and the operation stop time and date of the production robot 1 from the operation history database 33 to calculate the operation stop period, and determines whether the operation stop period is a predetermined period or longer. Examples of predetermined periods to be set include six hours, two days, ten days, and twenty days. The operation status determination unit 23 thus determines that there is the operation stop period when the production robot 1 is determined to have stopped the operation for six hours or longer. The process proceeds to step S111 when the production robot 1 is determined to have the operation stop period. The process proceeds to step 115 when the production robot 1 is determined to have no operation stop period.

[0032] In step S111, the suspension period setting unit 25 sets the malfunction determination suspension period during which the determination of a malfunction of the production robot 1 is suspended, depending on the length of the operation stop period. As shown in Fig. 4, the suspension period setting unit 25 sets the malfunction determination suspension period to be one hour when the operation stop period is six hours or longer and shorter than two days. Similarly, the suspension period setting unit 25 sets the malfunction determination suspension period to be half a day when the operation stop period is two days or longer and shorter than ten days, sets the malfunction determination suspension period to be two days when the operation stop period is ten days or longer and shorter than twenty days, and sets the malfunction determination suspension period to be five days when the operation stop period is twenty days or longer. The suspension period setting unit 25 thus sets the malfunction determination suspension period to be longer as the operation stop period is longer. The length of the malfunction determination suspension period, however, should have an upper limit so as not to allow the malfunction determination suspension period to exceed the upper limit even if the operation stop period is further extended. For example, the malfunction determination suspension period still needs to be set to five days if the operation stop period exceeds one month.

[0033] The malfunction determination suspension period is set immediately after the operation stop period, namely, set from the point at which the production robot 1 starts operating after the operation stop period ends. Fig. 3 illustrates a case in which the operation stop period for two days ends, the malfunction determination suspension period L1 is set

to half a day from the point at which the production robot 1 starts operating on July 4th.

[0034] In step S113, the malfunction determination unit 27 compares the malfunction determination value with the predetermined threshold in the period other than the malfunction determination suspension period so as to determine whether the production robot 1 has a malfunction. For example, the malfunction determination unit 27 determines whether the production robot 1 has a malfunction in the period other than the malfunction determination suspension period L1 set as shown in Fig. 3. In other words, the malfunction determination unit 27 determines whether the production robot 1 has a malfunction by use of the sensor data detected in the period other than the malfunction determination suspension period L1.

[0035] As shown in Fig. 3, the difference rate of the disturbance torque used as the malfunction determination value exceeds the threshold of 20% in the malfunction determination suspension period L1. The malfunction determination value does not exceed the threshold of 20% in the period other than the malfunction determination suspension period L1. The malfunction determination unit 27 thus determines that the production robot 1 has no malfunction. The process returns to step S101 when there is no malfunction, so as to acquire the sensor data for the period subsequent to the current malfunction determination to continuously execute the following malfunction determination. The process proceeds to step S115 when there is a malfunction.

[0036] When determining whether the production robot 1 has a malfunction, the malfunction determination unit 27 may analyze any other factor, in addition to the waveform of the malfunction determination value shown in Fig. 3, so as to determine a malfunction of the production robot 1 with the analysis result taken into consideration. For example, the malfunction determination unit 27 may execute the malfunction determination by use of another false-alarm avoidance logic, so as to determine a malfunction of the production robot 1 in accordance with the determination result.

[0037] In step S115, the malfunction determination unit 27 outputs an alarm via the user interface 5. For example, the malfunction determination unit 27 causes the user interface 5 to display the determination result of the malfunction or an alert picture on the display screen, or outputs an alarm sound. The malfunction determination unit 27 then stores the determination result of the malfunction and the output record of the alarm in the database, so that the malfunction determination processing by the malfunction determination device 3 according to the present embodiment ends.

[Effects of first embodiment]

[0038] As described in detail above, the malfunction determination method and device according to the present embodiment determines whether the production machine has an operation stop period during which the production machine has stopped its operation for a predetermined period of time or longer in accordance with the operation history of the production machine. When the production machine is determined to have the operation stop period, the malfunction determination suspension period for suspending the malfunction determination of the production machine is set in accordance with the length of the operation stop period, and the production machine is then determined whether to have a malfunction in the period other than the malfunction determination suspension period. The malfunction determination method and device thus can prevent false detection of a malfunction made under the circumstances having no relationship with the operational condition of the motor, such as when the production machine has not been operated for a long period of time.

[0039] When a production machine has not been operated for a long period of time, viscosity of lubricating oil, for example, typically tends to increase. This may lead to false detection of a malfunction even though there is no malfunction in the production machine, when the production machine has not been operated for a long period of time and then starts operating. The malfunction determination method and device according to the present embodiment thus determines whether the production machine has a malfunction in the period other than the malfunction determination suspension period, so as to prevent false detection of a malfunction as described above. The prevention of false detection can decrease the number of maintenance steps necessary for the production machine, leading to a reduction in maintenance cost accordingly.

[0040] The malfunction determination method and device according to the present embodiment sets the reference value based on the past sensor data so as to determine a malfunction of the production machine depending on whether the rate of change of the sensor data with respect to the reference value is a predetermined threshold or greater. The production machine can be determined to have a malfunction when the production machine has been greatly changed from the past state, so as to make a determination of a malfunction of the production machine more precisely. The precise determination can prevent false detection of a malfunction of the production machine more accurately.

[0041] The malfunction determination method and device according to the present embodiment stores the sensor data in the database, and acquires the sensor data stored in the database so as to determine a malfunction of the production machine. This enables the malfunction determination at optional timing after all data necessary for the malfunction determination is prepared. The malfunction determination method and device thus can make a determination of a malfunction of the production machine more precisely, so as to prevent false detection of a malfunction of the production machine more accurately.

[0042] The malfunction determination method and device according to the present embodiment uses the data of the disturbance torque applied to the motor as the sensor data used for the malfunction determination of the production machine. The determination of a malfunction of the production machine is executed in accordance with the result of sensing of the motor itself, so as to make a determination of a malfunction of the production machine more precisely.

The precise determination can prevent false detection of a malfunction of the production machine more accurately.

[0043] The malfunction determination method and device according to the present embodiment uses the data of the vibration value of the rotating mechanism as the sensor data used for the malfunction determination of the production machine. The determination of a malfunction of the production machine is executed in accordance with the result of sensing of the motor on the output side, so as to make a determination of a malfunction of the production machine more precisely. The precise determination can prevent false detection of a malfunction of the production machine more accurately.

[Second embodiment]

[0044] A second embodiment according to the present invention will be described below with reference to the drawings. The same elements illustrated in the drawings as used in the first embodiment are indicated by the same reference numerals, and specific explanations are not repeated below.

[Configuration of malfunction determination system]

[0045] Fig. 5 is a block diagram illustrating a configuration of a malfunction determination system including a malfunction determination device according to the present embodiment. As shown in Fig. 5, the present embodiment differs from the first embodiment in that the malfunction determination device 3 further includes an environmental temperature database 51.

[0046] The environmental temperature database 51 accumulates environmental temperature data of the production robot 1. While the present embodiment exemplifies the environmental temperature data which refers to the temperature of the production robot 1, the data does not necessarily concern the temperature of the production robot 1, and may refer to the temperature of a facility in which the production robot 1 is installed. Alternatively, the temperature in an area in which the facility is located may be acquired externally, such as on the Internet, for example and accumulated.

[0047] When the production robot 1 has an operation stop period, the suspension period setting unit 25 sets a malfunction determination suspension period for suspending the malfunction determination of the production robot 1 in accordance with the length of the operation stop period and the environmental temperature of the production robot 1. While the first embodiment is illustrated with the case of setting the malfunction determination suspension period only based on the length of the operation stop period, the suspension period setting unit 25 according to the present embodiment sets the malfunction determination suspension period based on both the length of the operation stop period and the environmental temperature of the production robot 1. The environmental temperature of the production robot 1 used for setting the malfunction determination suspension period is an average temperature of the production robot 1 in the operation stop period. The environmental temperature may be any of the average temperature of the production robot 1, the average temperature in the facility, and the average temperature in the area in which the facility is located.

[0048] When a production machine has not been operated for a long period of time, viscosity of lubricating oil, for example, typically tends to be increased. The viscosity of the lubricating oil further increases as an environmental temperature is lower. If the production machine has been stopped for a long period of time at a low environmental temperature and then starts operating, a probability of false detection that the production machine is determined to have a malfunction is increased even though there is no malfunction in the production machine. The suspension period setting unit 25 thus sets the malfunction determination suspension period depending on the length of the operation stop period and the environmental temperature of the production machine. In particular, the suspension period setting unit 25 sets the malfunction determination suspension period to be longer as the operation stop period is longer, and sets the malfunction determination suspension period to be longer as the environmental temperature is lower.

[0049] As shown in Fig. 6, the malfunction determination suspension period is set to two hours when the operation stop period of the production robot 1 is six hours or longer and shorter than two days at the environmental temperature of 10°C, and set to one hour at the environmental temperature of 30°C. The malfunction determination suspension period is set to one day when the operation stop period of the production robot 1 is two days or longer and shorter than ten days at the environmental temperature of 10°C, and set to half a day at the environmental temperature of 30°C. The malfunction determination suspension period is set to five days when the operation stop period of the production robot 1 is ten days or longer and shorter than twenty days at the environmental temperature of 10°C, and set to two days at the environmental temperature of 30°C. The malfunction determination suspension period is set to ten days when the operation stop period of the production robot 1 is twenty days or longer at the environmental temperature of 10°C, and set to five days at the environmental temperature of 30°C. The suspension period setting unit 25 thus sets the malfunction

determination suspension period to be longer as the operation stop period is longer, and sets the malfunction determination suspension period to be longer as the environmental temperature is lower.

[0050] Fig. 7 illustrates a case of setting the malfunction determination suspension period L1 to half a day when the operation stop period is two days and the environmental temperature is around 30°C. Fig. 8 illustrates a case of setting the malfunction determination suspension period L2 to one day when the operation stop period is two days and the environmental temperature is around 10°C.

[0051] While Fig. 6 illustrates the case in which the malfunction determination suspension period differs depending on the environmental temperature of 10°C or 30°C, the malfunction determination suspension period to be set may differ depending on the seasons, instead of the environmental temperature. For example, the malfunction determination suspension period to be set may differ between summer and winter, or may differ between spring, summer, fall, and winter.

[Malfunction determination processing]

[0052] A malfunction determination method by the malfunction determination device 3 according to the present embodiment is described below. The malfunction determination processing according to the present embodiment is similar to the malfunction determination processing according to the first embodiment as illustrated in Fig. 2. The operation status determination unit 23 according to the first embodiment only acquires the operation history data in step S107. According to the present embodiment, in step S107, the operation status determination unit 23 acquires the operation history data of the production robot 1 from the operation history database 33, and the suspension period setting unit 25 acquires the environmental temperature data of the production robot 1 from the environmental temperature database 51.

[0053] In step S111, the suspension period setting unit 25 sets the malfunction determination suspension period in accordance with the length of the operation stop period and the environmental temperature of the production machine, as described above. The other steps are the same as those in the first embodiment, and the malfunction determination processing by the malfunction determination device 3 thus ends.

[Effects of second embodiment]

[0054] As described in detail above, the malfunction determination method and device according to the present embodiment sets the malfunction determination suspension period in accordance with the length of the operation stop period and the environmental temperature of the production machine. This enables the setting of the malfunction determination suspension period with the influence by the temperature taken into consideration, so as to prevent false detection of a malfunction of the production machine more accurately.

[0055] The malfunction determination method and device according to the present embodiment uses the average temperature of the production machine in the operation stop period as the environmental temperature of the production machine. This enables the setting of the malfunction determination suspension period while reflecting the condition of the production machine in the operation stop period, so as to prevent false detection of a malfunction of the production machine more accurately.

[0056] The embodiments described above are examples of the present invention. It should be understood that the present invention is not intended to be limited to the above embodiments, and various modifications can be made, other than the above embodiments, within the scope of the appended claims.

REFERENCE SIGNS LIST

[0057]

1	PRODUCTION ROBOT
3	MALFUNCTION DETERMINATION DEVICE
5	USER INTERFACE
11	SENSOR
13	CALCULATION UNIT
15, 21	COMMUNICATION UNIT
23	OPERATION STATUS DETERMINATION UNIT
25	SUSPENSION PERIOD SETTING UNIT
27	MALFUNCTION DETERMINATION UNIT
29	SENSOR INFORMATION DATABASE
31	MAINTENANCE HISTORY DATABASE
33	OPERATION HISTORY DATABASE
51	ENVIRONMENTAL TEMPERATURE DATABASE

100 MALFUNCTION DETERMINATION SYSTEM

Claims

5 1. A malfunction determination method of a malfunction determination device (3) for determining a malfunction of a production machine (1) with a motor drive system including a motor as a driving source of a rotating mechanism, the method comprising:

10 acquiring sensor data of a sensor (11) for detecting a condition of the motor drive system;
determining whether the production machine (1) has an operation stop period during which the production machine (1) has stopped its operation for a predetermined period of time or longer in accordance with an operation history of the production machine (1);
15 when determined to have the operation stop period, setting a malfunction determination suspension period for suspending a malfunction determination of the production machine (1) to be longer as the operation stop period is longer, wherein the length of the malfunction determination suspension period has an upper limit so as not to allow the malfunction determination suspension period to exceed the upper limit even if the operation stop period is further extended; and
20 determining whether the production machine (1) has a malfunction in a period other than the malfunction determination suspension period by use of the sensor data for the period other than the malfunction determination suspension period.

25 2. The malfunction determination method according to claim 1, wherein the malfunction determination suspension period is set in accordance with the length of the operation stop period and an environmental temperature of the production machine (1).

3. The malfunction determination method according to claim 2, wherein the environmental temperature of the production machine (1) is an average temperature of the production machine (1) in the operation stop period.

30 4. The malfunction determination method according to any one of claims 1 to 3, wherein the malfunction determination of the production machine (1) is executed by setting a reference value based on past sensor data, and determining whether a rate of change of the sensor data with respect to the reference value is a predetermined threshold or greater.

35 5. The malfunction determination method according to any one of claims 1 to 4, further comprising storing the sensor data in a database (29), and acquiring the sensor data stored in the database (29) so as to execute the malfunction determination of the production machine (1).

40 6. The malfunction determination method according to any one of claims 1 to 5, wherein the sensor data used for the malfunction determination of the production machine (1) is data of a disturbance torque applied to the motor.

7. The malfunction determination method according to any one of claims 1 to 5, wherein the sensor data used for the malfunction determination of the production machine (1) is data of a vibration value of the rotating mechanism.

45 8. A malfunction determination device (3) for determining a malfunction of a production machine (1) with a motor drive system including a motor as a driving source of a rotating mechanism, the device being configured to:

50 acquire sensor data of a sensor (11) for detecting a condition of the motor drive system;
determine whether the production machine (1) has an operation stop period during which the production machine (1) has stopped its operation for a predetermined period of time or longer in accordance with an operation history of the production machine (1);
when determined to have the operation stop period, set a malfunction determination suspension period for suspending a malfunction determination of the production machine (1) to be longer as the operation stop period is longer, wherein the length of the malfunction determination suspension period has an upper limit so as not to allow the malfunction determination suspension period to exceed the upper limit even if the operation stop period is further extended; and
55 determine whether the production machine (1) has a malfunction in a period other than the malfunction determination suspension period by use of the sensor data for the period other than the malfunction determination suspension period.

Patentansprüche

1. Fehlfunktionsbestimmungsverfahren einer Fehlfunktionsbestimmungsvorrichtung (3) zum Bestimmen einer Fehlfunktion einer Produktionsmaschine (1) mit einem Motorantriebssystem, das einen Motor als Antriebsquelle eines Drehmechanismus aufweist, wobei das Verfahren folgende Schritte aufweist:

Erfassen von Sensordaten eines Sensors (11) zum Detektieren eines Zustandes des motorischen Antriebssystems;

Bestimmen, ob die Produktionsmaschine (1) eine Betriebsstoppperiode aufweist, während der die Produktionsmaschine (1) ihren Betrieb für eine vorgegebene Zeitspanne oder länger in Übereinstimmung mit einer Betriebsgeschichte der Produktionsmaschine (1) gestoppt hat;

wenn bestimmt wird, dass die Betriebsunterbrechungsperiode vorliegt, Einstellen einer Fehlfunktionsbestimmungs-Aussetzungsperiode zum Aussetzen einer Fehlfunktionsbestimmung der Produktionsmaschine (1), so dass sie länger ist, wenn die Betriebsunterbrechungsperiode länger ist, wobei die Länge der Fehlfunktionsbestimmungs-Aussetzungsperiode eine obere Grenze hat, um nicht zuzulassen, dass die Fehlfunktionsbestimmungs-Aussetzungsperiode die obere Grenze überschreitet, selbst wenn die Betriebsunterbrechungsperiode sich weiter erstreckt; und

Bestimmen, ob die Produktionsmaschine (1) eine Fehlfunktion in einer anderen Periode als der Fehlfunktionsbestimmungs-Aussetzungsperiode hat, durch Benutzen der Sensordaten für die andere Periode als die Fehlfunktionsbestimmungs-Aussetzungsperiode.

2. Verfahren zur Fehlfunktionsbestimmung nach Anspruch 1, wobei die Fehlfunktionsbestimmungs-Aussetzungsperiode in Abhängigkeit von der Länge der Betriebsunterbrechungsperiode und einer Umgebungstemperatur der Produktionsmaschine (1) eingestellt wird.

3. Verfahren zur Fehlfunktionsbestimmung nach Anspruch 2, wobei die Umgebungstemperatur der Produktionsmaschine (1) eine durchschnittliche Temperatur der Produktionsmaschine (1) während der Betriebsunterbrechungsperiode ist.

4. Verfahren zur Fehlfunktionsbestimmung nach einem der Ansprüche 1 bis 3, wobei die Fehlfunktionsbestimmung der Produktionsmaschine (1) durch Einstellen eines Referenzwertes basierend auf vergangenen Sensordaten und Bestimmen, ob eine Änderungsrate der Sensordaten in Bezug auf den Referenzwert ein vorgegebener Schwellenwert oder größer ist, durchgeführt wird.

5. Verfahren zur Fehlfunktionsbestimmung nach einem der Ansprüche 1 bis 4, ferner aufweisend das Speichern der Sensordaten in einer Datenbank (29) und das Erfassen der in der Datenbank (29) gespeicherten Sensordaten, um die Fehlfunktionsbestimmung der Produktionsmaschine (1) durchzuführen.

6. Verfahren zur Fehlfunktionsbestimmung nach einem der Ansprüche 1 bis 5, wobei die für die Fehlfunktionsbestimmung der Produktionsmaschine (1) benutzten Sensordaten Daten eines auf den Motor zugeführten Störmoments sind.

7. Verfahren zur Fehlfunktionsbestimmung nach einem der Ansprüche 1 bis 5, wobei als Sensordaten für die Fehlfunktionsbestimmung der Produktionsmaschine (1) Daten eines Schwingungswertes des Drehmechanismus benutzt werden.

8. Fehlfunktionsbestimmungsvorrichtung (3) zur Bestimmung einer Fehlfunktion einer Produktionsmaschine (1) mit einem motorischen System, das einen Motor als Antriebsquelle eines Drehmechanismus aufweist, wobei die Vorrichtung konfiguriert ist zum:

Erfassen von Sensordaten eines Sensors (11) zur Detektion eines Zustandes des motorischen Antriebssystems; Bestimmen, ob die Produktionsmaschine (1) eine Betriebsstoppperiode aufweist, während der die Produktionsmaschine (1) ihren Betrieb für eine vorgegebene Zeitspanne oder länger in Übereinstimmung mit einer Betriebsgeschichte der Produktionsmaschine (1) gestoppt hat;

wenn bestimmt wird, dass die Betriebsunterbrechungsperiode vorliegt, eine Fehlfunktionsbestimmungs-Aussetzungsperiode zum Aussetzen einer Fehlfunktionsbestimmung der Produktionsmaschine (1) so einzustellen, dass sie länger ist, wenn die Betriebsunterbrechungsperiode länger ist, wobei die Länge der Fehlfunktionsbestimmungs-Aussetzungsperiode eine obere Grenze hat, um nicht zuzulassen, dass die Fehlfunktionsbestimmung

mungs-Aussetzungsperiode die obere Grenze überschreitet, selbst wenn die Betriebsunterbrechungsperiode weiter erstreckt wird; und

Bestimmen, ob die Produktionsmaschine (1) eine Fehlfunktion in einer anderen Periode als der Fehlfunktionsbestimmungs-Aussetzungsperiode hat, indem die Sensordaten für die andere Periode als die Fehlfunktionsbestimmungs-Aussetzungsperiode benutzt werden.

Revendications

1. Procédé de détermination de dysfonctionnement d'un dispositif de détermination de dysfonctionnement (3) pour la détermination d'un dysfonctionnement d'une machine de production (1) avec un système d'entraînement de moteur comprenant un moteur comme source d'entraînement d'un mécanisme rotatif, le procédé comprenant :

acquérir des données d'un capteur (11) pour la détection d'un état du système d'entraînement de moteur ;
déterminer si la machine de production (1) a une période d'arrêt de fonctionnement au cours de laquelle la machine de production (1) a arrêté son fonctionnement pendant une période de temps prédéterminée ou plus longue, conformément à un historique de fonctionnement de la machine de production (1) ;

lorsqu'il est déterminé qu'il y a une période d'arrêt de fonctionnement, fixer une période de suspension de la détermination de dysfonctionnement pour la suspension d'une détermination de dysfonctionnement de la machine de production (1) de sorte que la période de suspension soit plus longue à mesure que la période d'arrêt de fonctionnement est plus longue,

dans lequel la durée de la période de suspension de la détermination de dysfonctionnement a une limite supérieure de manière à ne pas permettre à la période de suspension de la détermination de dysfonctionnement de dépasser la limite supérieure même si la période d'arrêt de fonctionnement est encore prolongée ; et

déterminer si la machine de production (1) présente ou non un dysfonctionnement au cours d'une période autre que la période de suspension de la détermination de dysfonctionnement en utilisant les données du capteur pour la période autre que la période de suspension de la détermination de dysfonctionnement.

2. Procédé de détermination de dysfonctionnement selon la revendication 1, dans lequel la période de suspension de la détermination de dysfonctionnement est fixée en fonction de la durée de la période d'arrêt de fonctionnement et d'une température ambiante de la machine de production (1).

3. Procédé de détermination de dysfonctionnement selon la revendication 2, dans lequel la température ambiante de la machine de production (1) est une température moyenne de la machine de production (1) pendant la période d'arrêt de fonctionnement.

4. Procédé de détermination de dysfonctionnement selon l'une quelconque des revendications 1 à 3, dans lequel la détermination de dysfonctionnement de la machine de production (1) est exécutée en établissant une valeur de référence basée sur des données antérieures du capteur, et en déterminant si un taux de changement des données du capteur par rapport à la valeur de référence est supérieur ou égal à un seuil prédéterminé.

5. Procédé de détermination de dysfonctionnement selon l'une quelconque des revendications 1 à 4, comprenant en outre le stockage des données du capteur dans une base de données (29), et l'acquisition des données du capteur stockées dans la base de données (29) afin d'exécuter la détermination de dysfonctionnement de la machine de production (1).

6. Procédé de détermination de dysfonctionnement selon l'une quelconque des revendications 1 à 5, dans lequel les données du capteur utilisées pour la détermination de dysfonctionnement de la machine de production (1) sont des données d'un couple perturbateur appliqué au moteur.

7. Procédé de détermination de dysfonctionnement selon l'une quelconque des revendications 1 à 5, dans lequel les données du capteur utilisées pour la détermination de dysfonctionnement de la machine de production (1) sont des données d'une valeur de vibration du mécanisme rotatif.

8. Dispositif de détermination de dysfonctionnement (3) pour la détermination d'un dysfonctionnement d'une machine de production (1) avec un système d'entraînement de moteur comprenant un moteur comme une source d'entraînement d'un mécanisme rotatif, le dispositif étant configuré pour :

acquérir des données d'un capteur (11) pour la détection d'un état du système d'entraînement de moteur ;
déterminer si la machine de production (1) a une période d'arrêt de fonctionnement, au cours de laquelle la
machine de production (1) a arrêté son fonctionnement pendant une période prédéterminée ou plus longue,
conformément à un historique de fonctionnement de la machine de production (1) ;

lorsqu'il est déterminé qu'il y a une période d'arrêt de fonctionnement, fixer une période de suspension de la
détermination de dysfonctionnement pour la suspension d'une détermination de dysfonctionnement de la ma-
chine de production (1) de sorte que la période de suspension soit plus longue à mesure que la période d'arrêt
de fonctionnement est plus longue,

dans lequel la durée de la période de suspension de la détermination de dysfonctionnement a une limite supé-
rieure de manière à ne pas permettre à la période de suspension de la détermination de dysfonctionnement
de dépasser la limite supérieure même si la période d'arrêt de fonctionnement est encore prolongée ; et

déterminer si la machine de production (1) présente ou non un dysfonctionnement au cours d'une période autre
que la période de suspension de la détermination de dysfonctionnement en utilisant les données du capteur
pour la période autre que la période de suspension de la détermination de dysfonctionnement.

FIG. 1

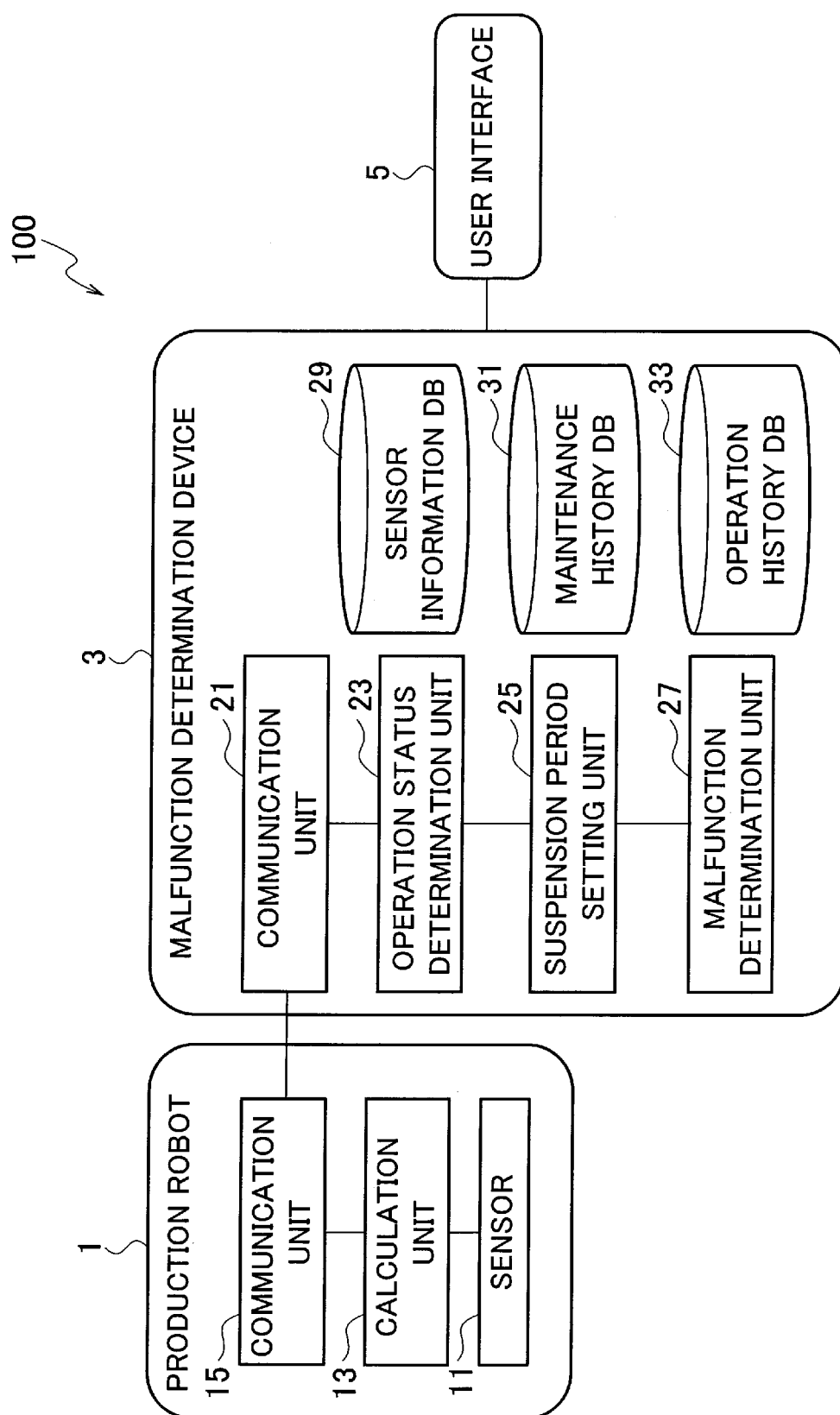


FIG. 2

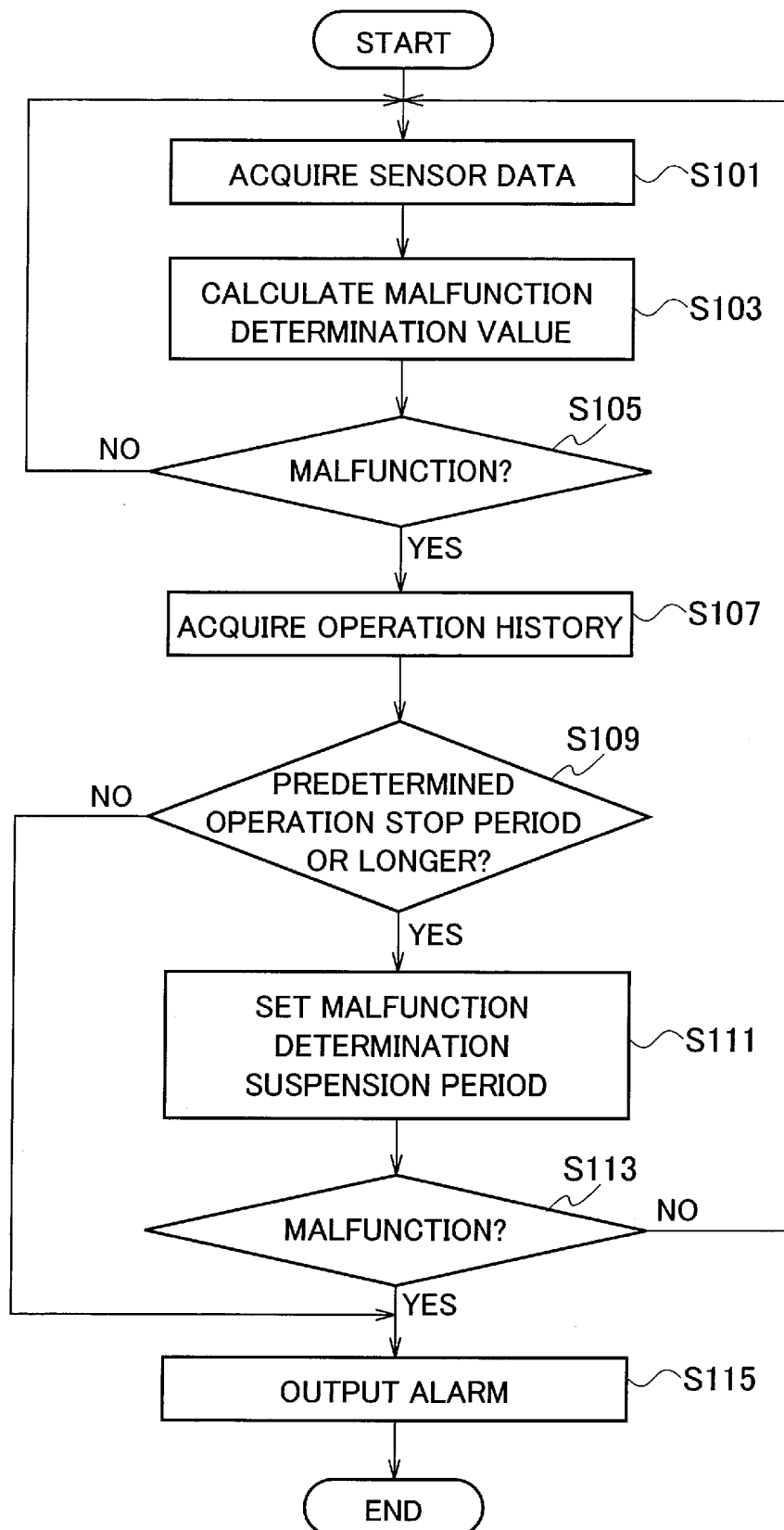


FIG. 3

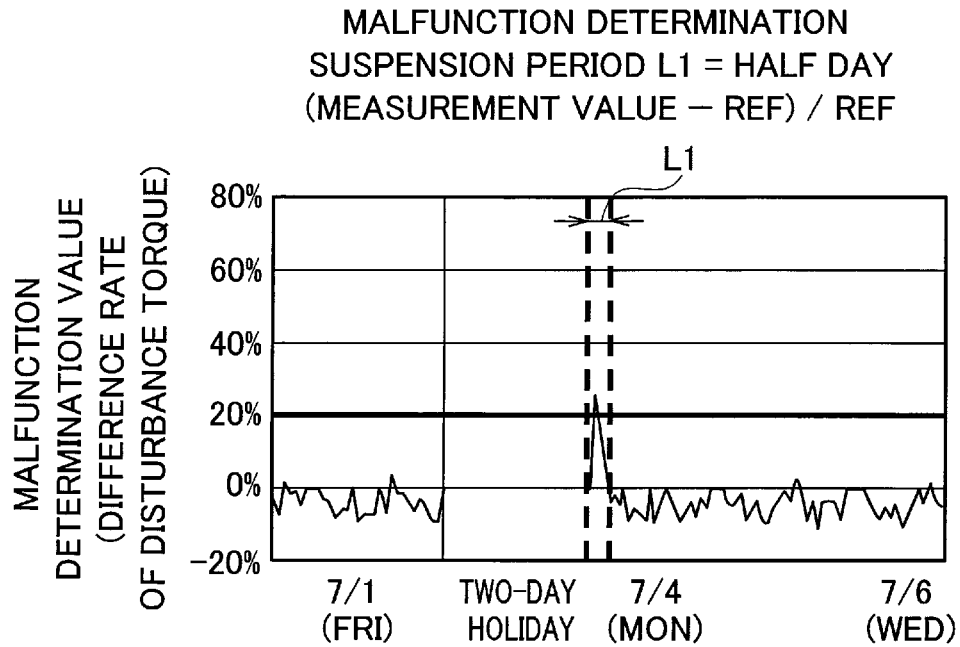


FIG. 4

OPERATION STOP PERIOD	6 HOURS	2 DAYS	10 DAYS	20 DAYS OR LONGER
MALFUNCTION DETERMINATION SUSPENSION PERIOD	1 HOUR	HALF DAY	2 DAYS	5 DAYS

FIG. 5

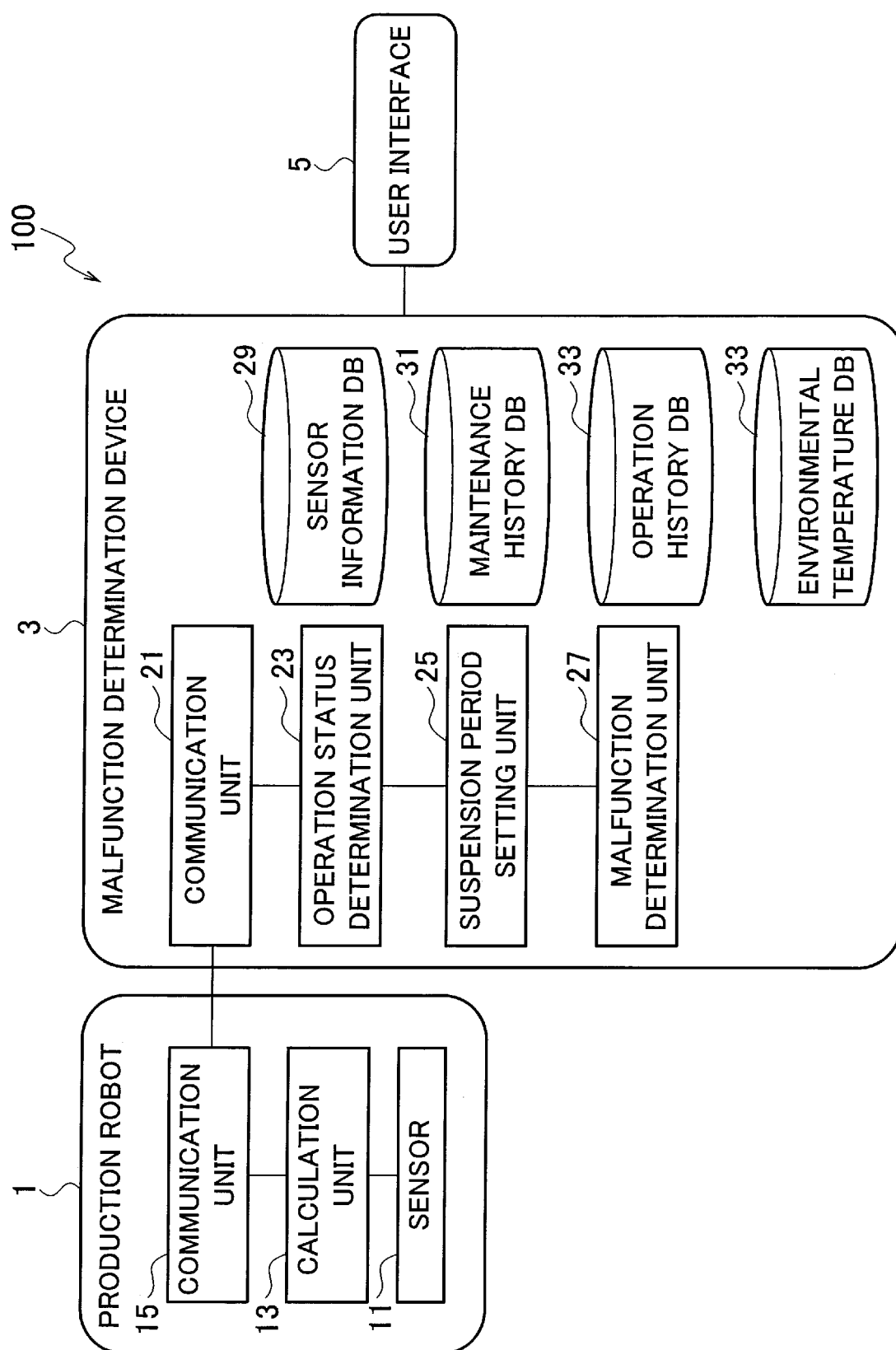


FIG. 6

OPERATION STOP PERIOD	6 HOURS	2 DAYS	10 DAYS	20 DAYS OR LONGER
MALFUNCTION DETERMINATION SUSPENSION PERIOD (ENVIRONMENTAL TEMPERATURE OF 10°C)	2 HOURS	1 DAY	5 DAYS	10 DAYS
MALFUNCTION DETERMINATION SUSPENSION PERIOD (ENVIRONMENTAL TEMPERATURE OF 30°C)	1 HOUR	HALF DAY	2 DAYS	5 DAYS

FIG. 7

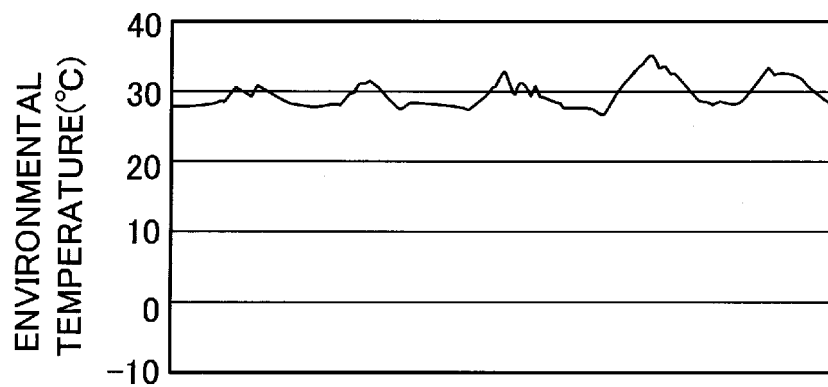
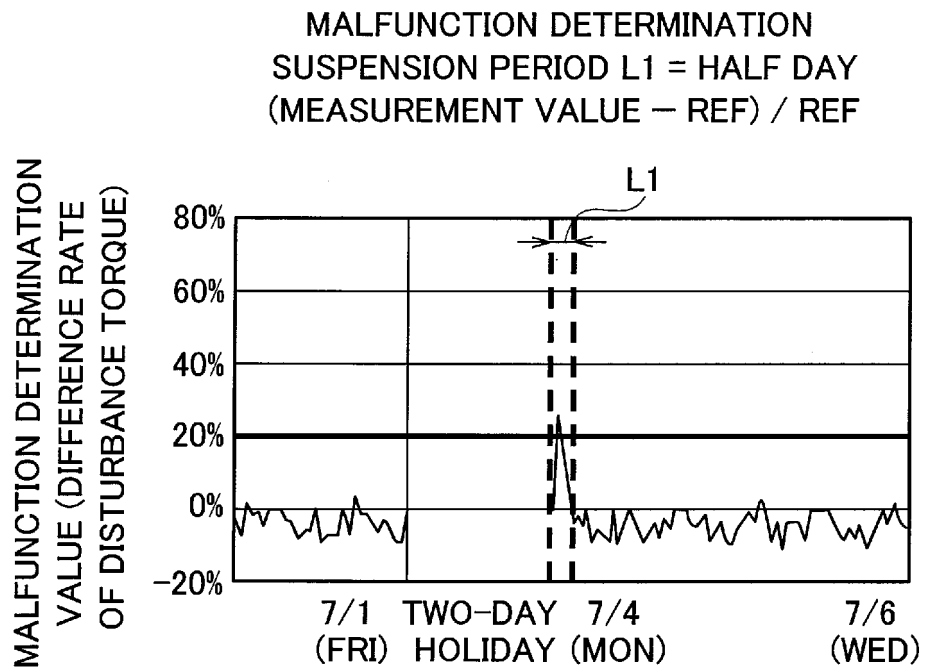
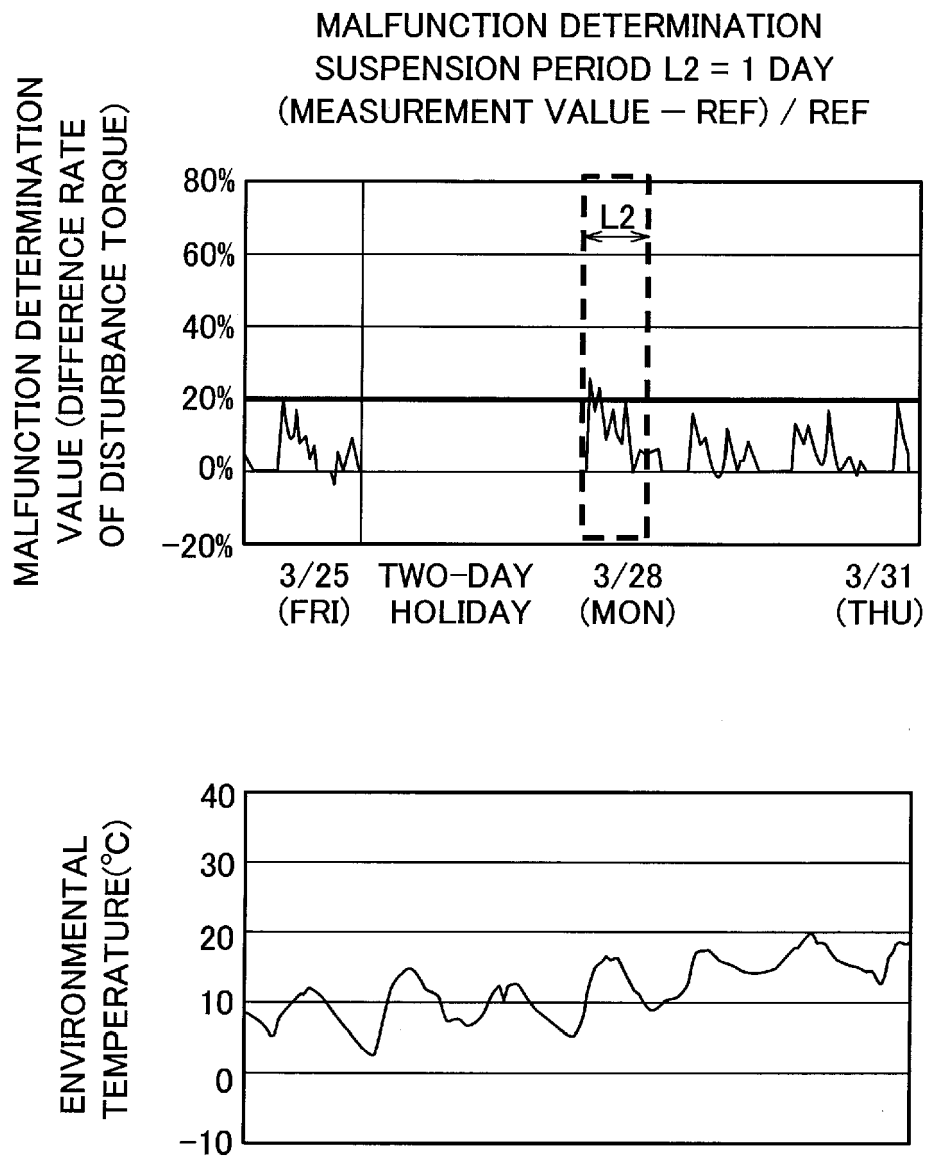


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2007219991 A [0003]
- JP 2002175104 A [0003]
- US 2007244609 A1 [0003]